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by

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AUTOMATED SYSTEMS FOR PLANNING AND MANAGEMENT IN TRANSPORTATION

DEMANDS ON A DATA TRANSMISSION SYSTEM

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Data transmission, to be understood here in the sense of data teletransmission, becomes necessary with the use of data teleprocessing and the direct communication between computers which as a hierarchy within the automated system of planning and management (ASL) have different, but interconnected, problems to solve. These forms of data processing will acquire increasing importance for

transportation. Conventional telex networks which can be used for data transmission (partially with supplementary equipment) are only conditionally suited especially for data processing systems with a real-time character and for computer hierarchies. Therefore in time special networks were created for individual data-processing systems (DP-systems) and computer connection systems. For a prospective solution, for economic, technical and technological reasons, only a uniform data transmission system for transportation of the GDR (subsequently called DT-system) is under consideration. The meeting of all demands which are made on DP-systems, especially by the ASL [1] require in such a DT-system the use of new technical equipment on the basis of computer technology. The DT-system unites the terminal devices and the transmission equipment of all DP-systems and takes into account the integration of existing networks or their component parts.

The following discourse describes the significant influencing factors, the fundamntal principles of design as well as the most important technical and technological requirements from a theoretical viewpoint for constructing such a DT-system.

1. FUNDAMENTAL DESIGN PRINCIPLES OF THE DT-SYSTEM

1.1. Scope and Structure of the System

A prospective DT-system for transportation encompasses data terminals and data transmission networks including matching equipment of the process computers for all transportation data teleprocessing systems (DTP-systems). It can be subdivided into the areas of terminal equipment and data transmission network.

The terminal equipment includes the data terminals as well as the matching equip ment for the network and process computer. The data transmission network includes transmission and relay equipment. The area of data acquisition is integrated into the DT-system only to the extent that it is technically realized in the data terminals. Thus all electrically (interrupted) [Tr. note: meaning of German word "abgesetzt" is unclear from context and available sources] for data acquisition devices do not belong to the DT-system. For process computer introduction all transmission systems are integrated which for their data input and output use conventional data acquisition technology or which are necessary for a connection to superior computers (guide computers).

Technologically the delimitation for the DT-system is given by the determination that only the offices, enterprises and organizations of transportation can become the users of such a

system. Therefore the proof of the economic value or the technological need of electrical data transmission is of primary importance for utilization (DTP-data teleprocessing).

1.2. Principle of Operation of the System

The use of a uniform DT-system through several DP-systems with various unequal conditions, taking into account economic and technological viewpoints, leads to the suggestion to use the principle of communication relay in the relay equipment of the system. In the case of the so-called line relay, as it is presently used in relay equipment, a direct connection is made between the transmitting and receiving terminal using special information which in principle is independent from the actual communication (activation of the dial switch). In the case of the principle of communication relay the "route information" is a direct component of the communication in the communication heading. The communication is relayed with this information from one relaying facility to another and in each case the favorable direction (if there are several possibilities) at this point in time and the sequence corresponding to varying priorities are determined taking into account engaged conditions and broken-down facilities.

For hardware and programming reasons it is expedient to divide

longer communications into individual "packets" of equal length and to transmit them in sequence. Intermediate storage is characteristic for this form (so-called "packet switching").

For the conditions of transportation of the GDR it can be estimated that the majority of DP-systems which are likely to come into use make the following technical and technological demands which can only be satisfied with the help of communication relaying:

- speed-, code- and format conversion,
- priority selection,
- intermediate storage of communications,
- check and control tasks,
- control of terminals by relaying facilities,
- control of satellite processers by guide computers,
- realization of direct access to data banks of various processing computers from any data terminals.

1.3 Network Design

In determining the network design the following significant factors are to be taken into account:

- size of the territory,
- topography of the data flow, i.e., the location of the data terminals as well as that of the EDP-installations and the process computers,
- the quantity of data to be transmitted,
- the time distribution of the data accumulation,
- time restrictions of the communications,
- structure of the DP-system,
- required transmission speeds,
- cost minimum for the transmission and relaying facilities.

On the basis of international trends [2] [3] and in accordance

with the conditions of transportation of the GDR the use of two levels of relaying facilities seems optimum (Fig.).

The lower level encompasses relaying facilities, so-called concentrators, to which terminal devices (to be understood here in the broader sense, since small computers and process computers can also be connected) can be connected in a radial pattern or through multi-party lines. They concentrate the data flow from the terminal devices into a few connections with higher transmission speed and distribute it in the opposite direction.

The upper level encompasses the so-called relay switching centers. The number of relay switching centers depends on the information flow to be processed and the realizable communication channels. While the concentrators, in principle, are connected to the relay switching centers in a radial pattern, in most cases a mixed network form (meshed and radial systems) turns out to be expedient for the connection of the relay switching centers to each other. The connection of the processing computer is possible as follows:

- central and regional EDP installations with a large data flow directly to the relay switching centers (typical computer coupling or wide-band transmission channels),

- central EDP installations with small data flow, through low-frequency transmission channels to the relay switching centers,

- regional EDP installations with small data flow, through low-frequency transmission channels to the relay switching centers or the concentrators,

- regional computers which, with their terminal devices, can be considered as subsystems, through concentrators to the DT-system.

2. IMPORTANT TECHNICAL REQUIREMENTS

2.1. Relaying Equipment

2.1.1. General Requirements

The following fundamental demands are to be made:

- the use of the principle of communication relaying with the target information in the communication heading,

- consideration of several priority classes for the communications,

- the realization of extremely short connection and disconnection times,

- the use of route control (automatic selection of the most favorable transmission link),

- the use of standardized code,

- the use of special services such as checking routine printout, statistics, collective communication, addition of dates and time,

- remote control including program loading of the concentrators through the relay switching centers,

- protection of the information to be transmitted from losses during damage,

- automatic switching to alternate connection during disturbances.

2.1.2. Limitation of the Working Range

The two intended types of relaying stations have different tasks in the system.

Scope of the Concentrator

- The connection of the terminal devices through a network of subscriber branch lines,

- the further carrying of information to the relay switching centers through connecting lines,

- control of the terminal devices to the extent necessary for the dialogue, terminal device-concentrator,

- control of data transmission to branch lines to the extent that it is not realized by isolated guided error protection equipment,

- control of data acquisition at the terminal devices to the extent that it is not already carried out in the terminal device,

- collaboration in the dialogue, concentrator - storage relay,

- intermediate storage of information in both transmission directions for the purpose of control, speed conversion, code conversion and format conversion,

- working out (if necessary) of special functions such as

subscriber identification, priority handling, etc.

Scope of the Relay Switching Center

- connection of the concentrators through a network of connecting lines,

- connection of the individual relay switching centers with each other through a network of connecting lines,

- conection of a EDP installation through special connecting lines,

- checking the mode of operation of the concentrators and regeneration of the service routine following disturbances,

- control of the dialogue, relay switching center - relay switching center,

- intermediate storage of information for the purpose of handling the communications (direction selection, etc.),

- control of the acceptance/transmission of information to the EDP installation (for this case eventually also speed conversion),

- control of data transmission on the connecting lines to the extent that it is not realized by isolated guided error protection.

2.1.3. Speed Conversion

In the uniform data transmission system two speed conversions are to be differentiated:

- speed conversion of the 1st type is realized in the concentrator; converts the various speeds of the terminal devices into a uniform transmission speed on the connecting lines,

- speed conversion of the 2nd type is realized in the relay switching center only for the case of transmission/acceptance of information from/to EDP installations either with higher speeds, typical for transmission ($\geqq$ 48 kbit/s) or typical for computers (bit-parallel) within buildings.

2.1.4. Reliability and Availability

The error rate of the relay stations, considered as part of the transmission path, should have a value of $P_Z \leqq 10^{-7}$. The reliability

of the relay stations as network nodes must be greater, the higher the relay station is in the network hierarchy.

The required availability can necessitate a doubling of the concentrators (hot reserve). A high availability is to be achieved through components and installation parts with high reliability and freedom from maintenance. These properties are to be supported through the use of checking and error-limiting programs from the side of the relay switching centers as well as through automatic disconnection of disturbed installation parts accompanied by remote signaling to the relay switching centers.

2.2. TRANSMISSION EQUIPMENT

2.2.1. Types of Connecting Lines

The future DT-system encompasses the following three types of connecting lines, whereby the demands to be made of the individual types (range, method of transmission, operating procedure, transmission rate, freedom from error of the transmission section, etc.) can be differentiated:

- subscriber connecting lines as a connecting path between terminal and concentrator,

- connecting lines between concentrator and relay switching centers as well as for connecting relay switching centers with each other (main network) and

- connecting lines between relay switching centers and process computers, which are designated as computer connecting lines.

The demands made of the subscriber connecting lines for the most part are directly dependent on the requirements of the special terminal equipment.

The last two types of connecting lines must meet the demands of all data processing systems which use the network.

2.2.2. Requirements

The following fundamental requirements are to be satisfied by all three types of connecting lines:

- the use of similar, standardized interfaces at the network nodes,

- the possibility of code-independent transmission,

- realization of low inherent distortion (attenuation and transit time distortions).

In addition for individual types there are fundamental special requirements:

- for the subscriber connecting lines: different speeds between 50 bit/s and 1200 bit/s as well as different error-protection procedures corresponding to the particular technological and technical conditions,

- for connecting lines in the main network: a uniform speed in the low-frequency transmission band (max. 9600 bit/s) and a uniform error-protection procedure on the basis of cyclical coding,

- for computer connecting lines: in addition to transmission in the low-frequency band, also transmission in wideband channels (e.g., 48 or 64 kbit/s) and computer coupling.

2.3. TERMINAL EQUIPMENT

2.3.1. Scope

The scope of the data terminals encompasses the input of data into the DT-system and its cutput in the opposite direction as well as, if necessary, the production of data carriers or the preparation of a communication for sending, the possibility of correction for data acquistion and transmission and the possibility of dialogue with the processing computers. One differentiates data terminals for converstional mode and for batch processing. From the standpoint of the trunking scheme a division can be made into trunk signalling operation and calling operation.

2.3.2. Fundamental Demands Made of Data Terminals

- code-independence,
- realization of a transmission speed,
- calling operation,
- unengaged operation,
- use and production of various data carriers,

- correction of acquired data,

- possibility of reporting and evaluation of fault reports,

- low error rate, low-noise operation and low-maintenance design.

2.3.3. Design of the Data Terminal

Through the different requirements of various ASL there results a wide spectrum of possible designs of data terminals. With the relatively small quantities to be expected per user it is not economically feasible with the high development costs to develop an individual data terminal for every special application. Rather, an attempt should be made to design an appropriate assortment of components which can be combined into various data terminals by the addition of a few specific components. The advantages of uniform equipment (operation and maintenance) and the manufacture of large quantities outweigh the savings in the case of specially adapted solutions.

A data terminal, from this viewpoint, can be divided into the functional groups of input/output devices, control unit and data transmission equipment.

For realizing the unit construction principle the establishment of uniform interfaces between the functional groups is necessary (this has already happened through international accords for the interface, control unit - DT-equipment).

The following are to be provided as input and/or output devices:

- punch tape devices,
- punch card devices,
- magnetic tape devices,
- displays,
- keyboards,
- printers,
- automatic readers (also automatic vehicle identification),
- automatic accounting machines.

The control unit likewise encompasses several component groups:

the most important are control panel, timing center, series-parallel converter, intermediate storage and operational control.

The functional group, "data transmission equipment" contains, as the most significant component, a signal converter which converts the data existing as direct-current signals into a form capable of being transmitted. Most frequently so-called modems are used for this which convert the data into audio-frequency signals so that they can be transmitted over any distance.

2.4. SPECIAL REQUIREMENTS FROM THE STANDPOINT OF THE ASL

In accordance with the stated goal ASL are being constructed in transportation in individual branches and enterprises. The following are to be considered significant for data transmission:

- realization of data exchange between the processing and process computers of different or equal levels on the basis of formalized dialogue,

- realization of a conversational mode, human - machine, whereby it is to be ensured that the terminal device can communicate with various processing computers,

- takeover of the processing tasks of a broken-down computer by a neighboring computer through a corresponding automatic further transmission of the information.

Because of the various types of the computers necessary for processing and their temporally staggered use, the transmission system permits universal communication through the use of uniform procedures and technical interface conditions.

3. QUESTIONS CONCERNING REALIZATION

The construction of a uniform DT-system for transportation of the GDR is an extensive, complicated and costly task which must be undertaken in unison with the stages of development and realization of ASL in transportation. In general it is estimated that in data teleprocessing systems the costs for the terminal devices and transmission equipment will far outweigh the costs for the EDP installations. Therefore the DT-system can only be realized in stages. This demand must also be met by the employed technique.

With the offering of a large number of ESER subscriber points the first step has already been made in the area of terminal technology. Here it is a question of expanding the palette of input and output devices, but at the same time of promoting standardization, especially of control units, in order to be able to

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use uniform procedures. In the area of relay technology it seems possible to use small computers or process computers as concentrators with appropriate equipment. For the realization of relay switching centers only EDP installations with special operating systems are under consideration.

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Fig. Fundamental Switching Scheme ((KEY: 1) Computer coupling to additional relay switching centers; 2) Central processing computer; 3) Level of the relay switching centers; 4) Regional processing computer; 5) Level of the concentrators; 6) Local processing computer; 7) Process computer; 8) Data terminals; 9) Subsystem; 10) Process.))